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ABSTRACT

This paper suggests that faculty at two-year institutions need to become partners with colleges of education and K-12 teachers of mathematics in preparing future mathematics teachers. The paper presents the following: a summary of recommendations on programs for prospective teachers; a summary of recommendations about mathematics courses for prospective teachers; a summary of recommendations for course content for future elementary mathematics teachers; a summary of standards for K-4 teacher preparation proposed mathematics curricula; mathematics content courses for preservice elementary teachers; a course outline for elementary mathematics teachers; course objectives for elementary mathematics teachers; mathematics activities that work (with accompanying directions and reproducible sheets); multicultural activities that provide mathematics education (with accompanying directions and reproducible sheets); and writing to learn activities. (SM)

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MATHEMATICS COURSES FOR THE PROSPECTIVE TEACHER

Presentation prepared by **Barbara C. Kistler**

for the 23rd Annual Conference
American Mathematical Association
of Two-Year Colleges
Atlanta, GA
November 15, 1997

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Participation/Sharing Opportunities

Mathematics for the Prospective Teacher

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Introduce yourself to at least one other person and share your interest in the topic of this session. Let your conversation be guided by the following questions:

1. Do prospective elementary school teachers have mathematics content course (s) designed for their particular needs at your institution?
Or do prospective teachers take courses created for a more general audience (liberal arts majors, etc.)? If so, what?

2. Are there any prerequisite courses or competencies to the required courses for future teachers at your institution? If so, what are they?

3. What textbook (s) or activity books are used in the required courses?

4. What changes, if any, would you like to make in the required courses for prospective teachers?

5. Do you use a particular "active learning " strategy in courses designed for prospective elementary school teachers? Explain.

6. Is there a laboratory component to your course where students do learning activities?

7. How is technology integrated into the required course (s)?

8. What are components of the assessment of students in the required mathematics content courses? Are writing/verbal /communication assignments included?
If so, explain and give examples.

SUMMARY OF RECOMMENDATIONS
PROGRAMS FOR PROSPECTIVE TEACHERS

Crossroads in Mathematics

American Mathematical Association of Two-Year Colleges
Barbara Kistler, Lehigh Carbon Community College

Programs For Prospective Teachers *(Crossroads in Mathematics* pp. 44-47)

Faculty, at two-year institutions, need to become partners with colleges of education and K-12 teachers of mathematics in the vital task of preparing future teachers of mathematics.

Content:

1. The mathematics studied by preservice teachers must help them develop an understanding of the subject that goes beyond what they will be expected to teach! They need to have "subject matter knowledge."

2. Prospective teachers should learn to:
   a. view mathematics as a system of interrelated principles
   b. communicate mathematics accurately, both orally and in writing
   c. understand the elements of mathematical modeling
   d. use calculators and computers appropriately
   e. appreciate the historical and cultural development of mathematics

3. Special mathematics courses for prospective elementary school teachers should revisit school mathematics topics. See the NCTM *Professional Standards for Teaching Mathematics* and MAA's *A Call for Change: Recommendations for the Mathematical Preparation of Teachers of Mathematics.*

4. All preservice teachers should acquire a broad background in the liberal arts and sciences.

5. Future teachers need to be prepared to help underrepresented students in mathematics to see the subject as part of their culture.

The Pedagogy:

1. Engage students in their learning.
2. Instructors need to take risks--explore new ideas, stimulate active discourse
3. Instructors need to be aware of the mathematical needs of prospective teachers, the major issues of the K-12 mathematics curriculum, new technology affecting mathematics education.
4. Technology must be integrated and appropriate to the course work.
5. Help students apply knowledge and develop in-depth understanding of central ideas.
6. Help students develop habits of the mind used by scientists and mathematicians.

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SUMMARY OF RECOMMENDATIONS FOR MATHEMATICS COURSES FOR PROSPECTIVE TEACHERS

NCTM's ***Professional Standards for Teaching Mathematics*** **(1991)**
MAA's ***A Call For Change: Recommendations For The Mathematical Preparations of Teachers of Mathematics (1991)***

Barbara Kistler, Lehigh Carbon Community College

1. No less than 9 semester hours of coursework in mathematics content is recommended for teachers of K-4. Assumed is a prerequisite of three years of high school mathematics for college-intending students or an equivalent preparation.

2. A minimum of 15 semester hours of college mathematics is recommended for teachers of grades 5-8. Assumed is a prerequisite of four years of high school mathematics for college-intending students or an equivalent preparation.

3. Teachers of secondary students need to have the equivalent of a major in mathematics. Assumed is a prerequisite of four years of high school mathematics for college-intending students or an equivalent preparation.

4. The specific content of the coursework for prospective elementary teachers is outlined on the following pages. Since the spirit as well as the content of these courses can be very different from traditional undergraduate-level courses, it is recommended that new courses be developed which reflect the recommendations.

5. The required mathematics-content courses for prospective elementary teachers need to be taught more conceptually. Emphasis needs to be placed on developing problem solving and higher thinking skills. The courses need to provide an opportunity for the learners to construct their own knowledge of mathematics, talk and discuss mathematics, and develop confidence in mathematics. Students need to see the broader picture of mathematics and where the elementary school curriculum connects.

6. Technology (calculators and computers) need to be integrated throughout the content courses. Future teachers need to become familiar with instructional technologies that provide powerful numerical, symbolic and graphical tools for the exploration, investigation and application of mathematics. Technology makes it possible to de-emphasize algorithmic skills and increase emphasis on mathematical concepts.

SUMMARY OF RECOMMENDATIONS
Content for courses designed for future elementary teachers
NCTM's ***Professional Standards for Teaching Mathematics*** p. 136
Barbara Kistler, Lehigh Carbon Community College

A. Number Systems and Number Sense
   1. mental mathematics and estimation
   2. number concepts, operations and properties--including basic number theory
   3. role of algorithms and place value
   4. development of real number system from natural numbers to rational numbers
   5. fractions, decimals, per cents, ratio and proportion

B. Geometry
   1. informal-used to solve real-world problems
   2. analysis of two and three dimensional figures
   3. synthetic, coordinate and transformational
   4. use of spacial visualization

C. Measurement
   1. attributes
   2. use of both standard and nonstandard units (estimate lengths, areas)
   3. understanding of metric system
   4. derivations of formulas for perimeter, area, and volume

D. Statistics and Probability
   1. collection, organization, representation, analysis and interpretation of data
   2. measures of central tendency
   3. measures of variation
   4. representations of data-graphs
   5. probability of simple and compound events
   6. empirical probability from simulations

E. Functions and use of Variables
   1. development of mathematical language and symbolism
   2. representing and solving problems using variables
   3. functions
   4. different representations of functions-tabular, graphical, symbolical, verbal
   5. distinction between continuous and discrete approaches

SUMMARY OF RECOMMENDATIONS
Standards for K-4 Teacher Preparation Proposed Curricula
MAA's *A Call For Change: Recommendations for the Preparation of Teachers of Mathematics* (pp. 12-16)

Barbara Kistler, Lehigh Carbon Community College

Standard 1: Nature and Use of Number

The mathematical preparation for teachers of the elementary grades must provide experiences in which they:

- investigate the role of numbers as a logical, predictable system for expressing and relating quantities;
- analyze and compare features and basic computational techniques in selected numeration systems in use today and in the past;
- explore the operations, properties, and uses of whole numbers, fractions, and decimals;
- use estimations and mental arithmetic, calculators, computers, paper-and-pencil algorithms, and manipulative materials, in solving a wide variety of problems.

Standard 2: Geometry and Measurement

The mathematical preparation for teachers of the elementary grades must provide experiences in which they:

- use a variety of tools, physical models, and appropriate technology to develop an understanding of geometric concepts and relationships and their use in describing the world in which we live;
- make and interpret measurements of many kinds of two-and three-dimensional objects;
- formulate and solve problems whose solutions require spatial sense.

Standard 3: Patterns and Functions

The mathematical preparation for teachers of the elementary grades must provide experiences in which they:

- recognize the study of patterns as an underlying, fundamental theme in mathematics;
- create and use pictures, charts, and graphs to recognize and describe mathematical relationships;
- discover and analyze functional relationships which arise from diverse problem situations;
- develop the use of variables and other algebraic notation as an efficient and natural way to describe relationships.

Standard 4: Collecting, Representing, and Interpreting Data

The mathematical preparation for teachers of the elementary grades must provide experiences in which they:

- collect and interpret data represented in different ways;
- conduct sampling experiments to develop an appreciation for randomness;
- explore empirical probability from data they have collected and relate it to theoretical probability based on a description of the underlying sample space;
- explore and compare various methods for representing data, both by hand and by using calculators and computers.

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MATHEMATICS CONTENT COURSES FOR PRESERVICE ELEMENTARY TEACHERS

Compiled from research documents

Barbara Kistler, Lehigh Carbon Community College

COURSE OBJECTIVES
Mathematics for Elementary Teachers I

1. Use problem-solving processes to investigate and understand the content of this course.

2. Develop and apply problem-solving strategies to solve a variety of problems. Use of calculator and computer environments in problem solving.

3. Use inductive and deductive reasoning, logic and set theory, not only for the purpose of problem solving, but also to produce a realization of the part played by each in the development of mathematics.

4. Understand relations, functions and use of the variable to model and solve problems.

5. Analyze and compare features and basic computational techniques in selected numeration systems in use today and in the past.

6. Explore and understand the basic concepts and operations of whole numbers, integers, rational numbers and real numbers. Use mental computation, estimation and calculator skills.

7. Use number theory to investigate and develop ideas about the nature of numbers.

COURSE OUTLINE
Mathematics for Elementary Teachers II
Compiled from Research
Barbara Kistler, Lehigh Carbon Community College

A. Geometry
    1. Geometry as a mathematical system
    2. Points and lines on a plane
    3. Constructions
    4. Polygons and tessellations
    5. Polyhedra and three-dimensional shapes
    6. Networks, graphs, and topological equivalence
    7. Logo (or some other environment) as a tool in geometry

B. Logo
    1. Logo commands
    2. Defining procedures
    3. Recursion
    4. Exploration and problem solving

C. Coordinate Geometry
    1. Graphs of functions
    2. Linear functions
    3. Systems of linear equations
    4. Coordinate geometry and Logo or use of graphics calculator

D. Measurement
    1. Metric system
    2. Concept of measurement
    3. Measures of plane figures
    4. Pythagorean relationship
    5. Measures of three-dimensional figures

E. Probability
    1. Concept of probability
    2. Sample spaces and events
    3. Computation of probability
    4. Conditional probability
    5. Independent events and simulations
    6. Odds and mathematical expectations
    7. Methods of counting—permutations and combinations

F. Statistics
    1. Statistical graphs
    2. Measures of central tendency
    3. Measures of dispersion
    4. Percentiles
    5. Normal distribution

COURSE OBJECTIVES
Mathematics for Elementary Teachers II
Compiled from Research
Barbara Kistler, Lehigh Carbon Community College

1. Solve problems in two- and three-dimensional geometry involving parallelism, perpendicularity, congruence, similarity, translation, reflection, rotation and symmetry.

2. Use the computer as a tool for solving problems and for exploring and developing geometrical concepts and relationships.

3. Solve problems using algebraic concepts of function and coordinate geometry.

4. Develop expertise and understanding of the process of measurement, including metric units.

5. Collect, organize, represent, analyze and interpret data using simple statistical methods.

6. Apply methods of probability and inference to real-world situations.

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COURSE OUTLINE
Mathematics for Elementary Teachers I
Compiled from Research
Barbara Kistler, Lehigh Carbon Community College

A. Problem Solving
    1. Critical thinking and inductive reasoning—exploration with patterns
    2. Problem solving process and strategies
    3. Problem solving using calculator and/or computer
    4. Logic and deductive reasoning used in problem solving
B. Set Theory and Functions
    1. Set notation
    2. Describing sets
    3. Set operations and their properties
    4. Relations and functions
C. Numeration
    1. History of numeration systems
    2. Using exponents
    3. Whole numbers as a mathematical system
    4. Algorithms for whole number operations
    5. Mental math and estimation strategies
    6. Computation in different bases
D. Systems of Integers
    1. Integers as a mathematical system
    2. Addition and subtraction of integers
    3. Multiplication and division of integers
    4. Solving equations and inequalities
E. Number Theory
    1. Divisibility
    2. Prime and composite numbers
    3. Prime factorization
    4. Greatest common divisor and least common multiple
    5. Modular arithmetic
F. System of Rationals
    1. Symbols and definitions
    2. Location on number line
    3. Operations defined on set of rationals
    4. Properties of the system of rational numbers
    5. Fractions, decimals, percents and scientific notation
    6. Ratios and proportions
G. System of Reals
    1. Introduction of irrational numbers
    2. Graphs on the number line of the set of real numbers
    3. Decimal representation of all the reals
    4. Properties of the system of real numbers

The selection and creation of the tasks with which the teacher engages the student in studying mathematics is the decision that has the greatest impact on students' opportunity to learn and on their perceptions about mathematics! The teacher is the architect of the curriculum.

Fouria Coin Trading

Game Sheet

Blue 4 red = 1 blue	Red 4 white = 1 red	White

Activities that Work!
Mathematics for the Prospective Teacher
Barbara Kistler, Lehigh Carbon Community College

A Visit To Fouria

(From Activity Book accompanying *Mathematics Activities for Elementary School Teachers* by Dolan, Williamson, & Muri)

Purpose:
This activity uses a model to reinforce place value concepts, to introduce the base four system of numeration, and to develop understanding of the trading process in addition and subtraction.

Materials: a die, red, blue and white chips, game and score sheet for 2 players

While on an Intergalactic Numismatics Tour you encounter a meteor shower and are forced to make an unscheduled stop on the planet Fouria. The monetary system used on Fouria consists of three coins, a white coin (worth $1 in our money), a red coin, and a blue coin. The red coin is equivalent in value to four white coins, and the blue coin is equal to four red coins.

Game 1
Unlike its sister planet, Ufouria, Fouria turns out to be a rather dull place to visit. To help pass the time, you and a fellow passenger play the coin trading game. The rules of the game are:
A. Players alternate turns.
B. On each turn, a player rolls one die and places that number of white Fourian coins in the White column on a Coin Trading Game Sheet.
C. Whenever possible , a player must trade four white coins for one red coin and /or four red coins for one blue coin.
D. Coins must always be placed in the appropriately labeled column, and no more than three of any of the coins may be in any column at the end of a turn.
E. The first player to get two blue coins is the winner.
F. At the end of each turn, record the number of each color coin on your game sheet.

Game 2
A. Start the game with three blue coins and remove white coins equal to the number rolled on each turn.
B. The first player to remove all the coins from the playing board is the winner.
C. At the end of each turn, record the number of each color coin on your game sheet.

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Fouria Player Record

Player 1

Turn	Number Rolled	Result		
		B	R	W
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				

Player 2

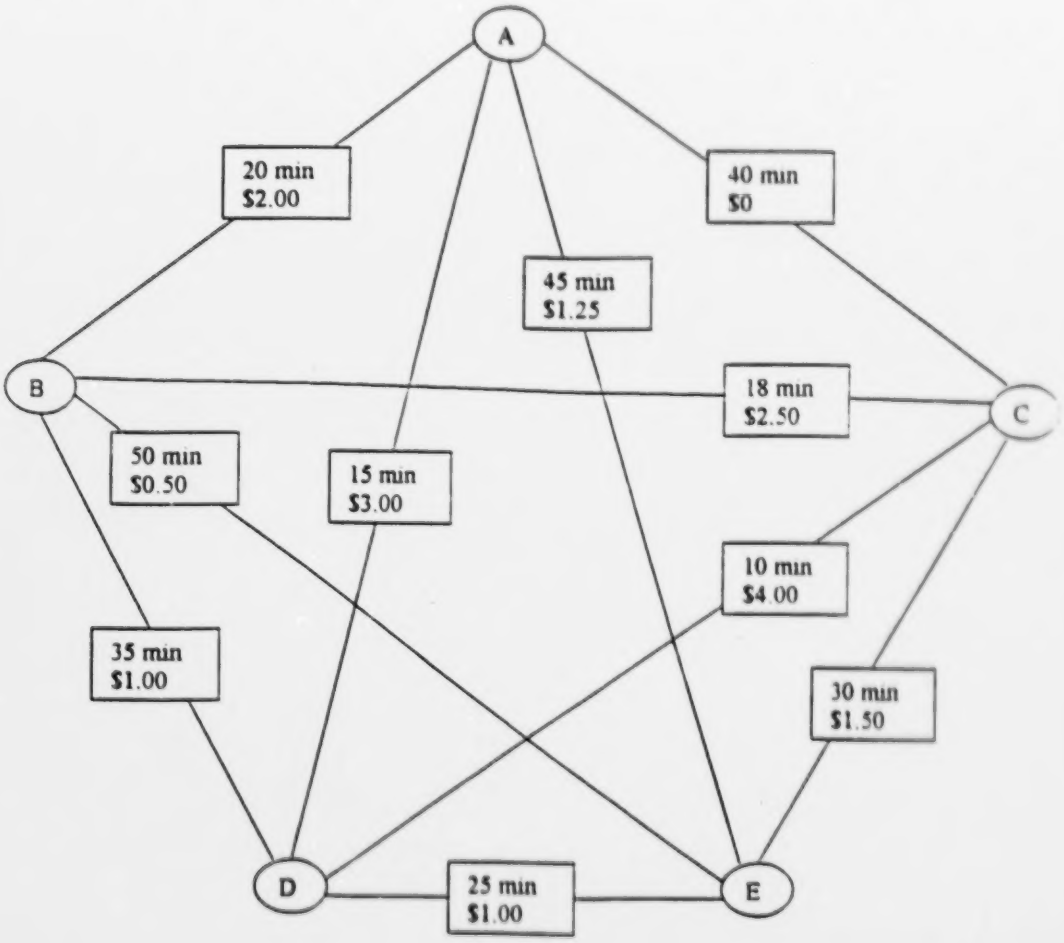
Turn	Number Rolled	Result		
		B	R	W
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				

Activities that Work!

Mathematics for the Prospective Teacher

Barbara Kistler, Lehigh Carbon Community College

Mathematics often helps us find the best method for solving some problems. It may be to maximize profit or minimize the time we spend traveling to various destinations. Suppose you own four vending machines which you must regularly visit to refill and collect money. You live at location A and the machines are located at B, C, D, and E. The lines connecting these points in the diagram below show how much time it takes to go from one to another and the expenses incurred. For example, it takes 20 minutes to go from A to B and costs $2.00. Determine the best route, starting and finishing the route at your home. Write at least two paragraphs explaining how and why you determine your route. Are you maximizing or minimizing costs or time?



Activities that Work!
Mathematics for the Prospective Teacher
Barbara Kistler, Lehigh Carbon Community College

(This activity leads very nicely into a discussion of apportionment methods such as Hamilton, Jefferson, and Webster and gives students the sense of empowerment as well as insight into an evolving branch of mathematics.)

Is it "fair"?

Mathematics is used to study human behavior, values, conflicts and decision making. Apportionment problems occur when resources must be allocated in integer quantities. The most important apportionment problem is the allocation of seats in the U.S. House of Representatives to the 50 states. Even George Washington, as President, had to deal with the mathematical aspects of apportionment to Congress!

Imagine your group is a committee given the task of assigning classes in a school district with declining enrollments as shown by the enrollment figures in the table below:

Grade:	Projected Enrollment:
First	64
Second	138
Third	142
Fourth	188
Fifth	218
Total	750

Prepare a poster for the school board in which you recommend the number of teachers to be assigned to each grade level under each of the following conditions:

a. The budget will allow the district to pay for 31 teachers.
b. The budget will allow the district to pay for only 30 teachers.

Include a description of the method you used to determine the assignment of teachers to grades. Use mathematics to verify your decision. Anticipate questions or objections from the board, teachers or parents.

Let's Make A Deal!

Purpose: Explore probability by doing a simulation.

Materials: Three 3X5 cards with words (and/or pictures) designating a BMW, and two goats
Recording sheet

You are on a game show. You are given the option of choosing one of three doors. Behind one door is a new BMW. Behind the other two doors is a goat. After choosing one of the three doors (don't open it yet) the MC, who knows where the car is located, opens one of the two remaining doors to reveal a goat. He asks you if you want to stay with your choice of door or switch to the remaining door. Do you think it is best to stay with your first choice of door, to change to the remaining door, or it makes no difference?

This simulation game will help you make the decision. Play this with a partner. One person will be the MC and the other will be the contestant. The MC puts the cards face down and knows where the BMW is located. Play the game 30 times. For the first 15 times the contestant should stay with the original choice. For the next 15 he/she should always switch doors after the MC shows where a goat is located. You should record the results in terms of winning the car or losing it. The MC should "shuffle" the cards each time.

Find the experimental probability of winning the car when you stay with your first choice.

Find the experimental probability of winning the car when you switch to the remaining door.

Based on your experiment, should you stay or switch? Why?

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Multicultural Activity

Egyptian Multiplication

Mathematics for the Prospective Teacher

Barbara Kistler, Lehigh Carbon Community College

The ancient Egyptian's method of multiplying is based on doubling. Here's how it worked. Note that Egyptian kids didn't have to know multiplication tables!!

Suppose you wanted to multiply 11 X 29.
Place the number 1 in the first row of the left column and the number 29 in the first row of the right column.

Double the numbers in both columns, placing the results in the second row.

Continue the doubling process until the number in the left column is greater than or equal to 11.

Circle the numbers in the left column that add up to 11.

Add up the numbers in the right column that correspond to the circled numbers. This will give the product of 11X 29.

Try: 13 X 15 and 16 X 41

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Multicultural Activity

Hypatia-Mother of Algebra

Mathematics for the Prospective Teacher

Barbara Kistler, Lehigh Carbon Community College

Hypatia, an Egyptian woman born in 370 AD, is remembered for her life as a mathematician, scientist, and teacher. She was a professor at the famous university of Alexandria and was considered one of the great lecturers in this center of learning. Besides preserving the algebra of her day and inventing an instrument for measuring the positions of the stars and planets, Hypatia studied number patterns and their relationship to geometric figures. You can experiment with some of these patterns.

1. With three toothpicks create an equilateral triangle. Count the number of "nodes" or places where the toothpicks meet. Then add toothpicks to each side to form an equilateral triangle around the smaller one with each side two toothpicks long. Count the "nodes."

2. Continue adding toothpicks to each side around the existing triangle to create a larger equilateral triangle with sides one toothpick larger than the previous one. Always count the "nodes" or places where the toothpicks meet.

Record results here and look for a pattern to continue:

1, 3, 6, ___, ___, ___, ___, . . .

These are called triangular numbers.

3. With four toothpicks create a square. Count the number of nodes. Add toothpicks to each side forming a square around the existing one with side length of two toothpicks. Count the number of nodes.

4. Continue adding toothpicks in the same manner. Don't count a node twice. Record results here and look for a pattern. These are called square numbers.

1, 4, 9, ___, ___, ___, ___, . . .

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Multicultural Activity

MANCALA-An African Game

Mathematics for the Prospective Teacher

Barbara Kistler, Lehigh Carbon Community College

Mancala is actually a name given to a family of games which have been played in Africa and the Middle East for thousands of years. To make a mancala board, use an egg carton, a bowl at each end and markers of any sort or color.

Two players begin by placing 3 markers in each of the 6 egg cups along his/her side of the board (egg carton). The color of the pieces doesn't matter. Players alternate turns. On each turn you pick up the pieces from one of the egg cups and distribute them one at a time moving counter-clockwise to each of your spaces, your bowl (or mancala--storehouse) and your opponent's spaces. You never add to your opponent's storehouse (bowl). If your last marker ends up in your own store, you get a free turn!

If your last piece ends up in an empty space on your side of the board, you have captured all the pieces in the space directly opposite. Collect them and put them in your store along with the single piece of yours that made the capture. That ends your turn.

The game ends when all six of your spaces are empty. If you are the player who ends the game, then your opponent gets to place all of the pieces left in his six spaces in his store. In other words, it is not in your best interest to end the game. Your score is the number of markers in your store.

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Activities that Work!
Mathematics for the Prospective Teacher
Barbara Kistler, Lehigh Carbon Community College

In a week you will hand in a 2-4 page document which will include typed narration and visual representations of data called boxplots. Boxplots are described on pages 231 and 232 in your textbook. Please read this material to learn how to create them and answer the questions on the back of these instructions before collecting your data with a game called *Pig*. Once you have completed the questions on the back begin work on your project by following these procedures. Also on the back is the grading rubric for this assignment.

1. Play the *Pig* game. Roll a standard dice as many times as you want and add the numbers from each roll. However, if you roll a 1, you get 0 points for your entire turn. For example, if you roll 6,6,3,4, and 2 (and then decide to stop), your score is 21. If you roll 6,6,3,4,2, and 1 your turn ends and your score is 0. Can you see where the name *Pig* comes from? Each game consists of 10 turns. Add the number of points obtained from the 10 turns. Play several games initially and devise a method of recording the results. What strategy will produce the highest score?

2. Once you have played the game to get a sense of the what strategies would be best, write several paragraphs describing how the game is played, how you recorded your results and any observations or suggested strategies which you think will produce the highest score over time. On average, how many times did you roll before a 1 occurs? Use complete sentences and write as if you were addressing someone who has never heard of the game.

3. You will perform an experiment which will compare two strategies of this game using boxplots. Collect the data for 20 games (remember a game is 10 turns) stopping each time at 4 rolls (or less if a 1 is obtained before then). Construct a histogram and compute the mean and standard deviation (use a calculator!). Make a boxplot. (Remember to show the scale and label the 5 number summary.)

4. Repeat the experiment except stop each turn at 5 rolls (or less if a 1 comes up). Collect the data for 20 games. Construct a histogram and compute the mean and standard deviation. Make a boxplot of this experiment next to or below the one created in step 3 (use the same scaling on the same piece of paper).

5. In the project, report your results of the two experiments and write your analyses of what the side-by-side boxplots tell us. What does looking at the histogram, mean and standard deviation of each experiment tell us about the two strategies? Summarize any final observations or conclusions.

****Bonus Point--Find when boxplots were first used and who "invented" them. Give source or website when reporting this.*

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Boxplot Activity
Questions for Understanding

1. A boxplot is created using a five-number summary. Name the five numbers and describe how to calculate each.

2. The whiskers of a boxplot extend to what two numbers?

3. What are some advantages of using boxplots to describe data?

4. What percent of the data lies "in the box" of a boxplot that is between the first and third quartiles?

Boxplot Activity
Grading Procedures

This project is worth 15 points. The number of points you earn will be based on the following criteria.

1. Accuracy/Content
   Is the description of the game accurate and understandable?
   Is your recording scheme workable and explained well ?
   Did you include the data you collected?
   Are the experiments and calculations done correctly?
   Are the boxplots and histograms constructed neatly with correct labeling?
   Does your analysis agree with the descriptive tools created?
   Bonus for finding and referencing when boxplots were first used and who "invented" them.

2. Style/Organization
   Is there an introduction and explanation of what the reader can expect?
   Are all parts of the project addressed?
   Are the explanations clear and to the point?
   Are there enough details in the narration?

3. Conventions
   Is the project typed and generally free of grammatical and spelling errors?
   Bonus if histograms are completed using spreadsheet software.

Writing to Learn
Mathematics for the Prospective Teacher
Barbara Kistler, Lehigh Carbon Community College

Mathematics History

Learning Log

Minute Cards

"Papers" on Mathematics Topics

Oral Classroom Presentations

Poster

Essay questions on tests

Daily opportunities for short oral explanations

Design and report on surveys

Journal article summaries and critiques

Newspaper article "reaction" paper

Create a game for an elementary school class; write clear explanations

Research a mathematics topic "on-line"

Dialogs or fictional "interviews" with famous mathematicians

Interview persons using mathematics in some specific way in their vocation

Write and design a mathematics children's book